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EDGEWOOD ARSENAL TECHNICAL REPORT

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THE EFFECTS OF DDT, DDE, AND THEIR SULFONATED DERIVATIVES ON EGGSHELL FORMATION IN THE MALLARD DUCK

by

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February 1977

DEPARTMENT OF THE ARMY
Headquarters, Edgewood Arsenal
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REPORT DOCUMENTATION PAGE

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1. REPORT NUMBER
14 EB-TR-76116

2. GOVT ACCESSION NO.

3. RECIPIENT'S CATALOG NUMBER

4. TITLE (and Subtitle)
6 THE EFFECTS OF DDT, DDE, AND THEIR SULFONATED DERIVATIVES ON EGGSHELL FORMATION IN THE MALLARD DUCK.

5. TYPE OF REPORT & PERIOD COVERED
9 Technical Report, Dec[redacted]75–Mar[redacted]76,

6. PERFORMING ORG. REPORT NUMBER

7. AUTHOR(s)
10 Gerald J. Kolaja D.V.M., CPT, VC

8. CONTRACT OR GRANT NUMBER(s)

9. PERFORMING ORGANIZATION NAME AND ADDRESS
Commander, Edgewood Arsenal
Attn: SAREA-BL-VP
Aberdeen Proving Ground, Maryland 21010

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
EPA Project 12 10p.

11. CONTROLLING OFFICE NAME AND ADDRESS
Commander, Edgewood Arsenal
Attn: SAREA-TS-R
Aberdeen Proving Ground, Maryland 21010

12. REPORT DATE
11 Feb[redacted]77

13. NUMBER OF PAGES
13

14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)

15. SECURITY CLASS. (of this report)
UNCLASSIFIED

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE
NA

16. DISTRIBUTION STATEMENT (of this Report)

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Copies available from: National Technical Information Service, Springfield, Virginia 22151.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)
DDT
DDE
Sulfonates
Eggshell formation

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The effects of DDT, DDE, and their sulfonated derivatives were studied for their effects on eggshell formation. Although DDT and DDE were found to decrease eggshell thickness and weight and to cause a reduction in R-values, the sulfonated derivatives did not share these properties. Sulfonation of DDT and DDE results in substantially less toxic products with regards to eggshell formation.

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PREFACE

The work described in this report was authorized under an Environmental Protection Agency project. This work was started in December 1975 and completed in March 1976.

In conducting the research described in this report, the investigator adhered to the "Guide for the Care and Use of Laboratory Animals" as promulgated by the Committee on Revision of the Guide for Laboratory Animals Facilities and Care of the Institute of Laboratory Animal Resources, National Research Council.

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Acknowledgment

I wish to acknowledge the assistance of Mr. Elden Leighton in the computer programming and Dr. Jerry F. Hardisty in the statistical analysis of the data.

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THE EFFECTS OF DDT, DDE, AND THEIR SULFONATED DERIVATIVES ON EGGSHELL FORMATION IN THE MALLARD DUCK

I. INTRODUCTION.

The effects of 2,2-bis-(p-chlorophenyl)-1,1,1-trichloroethane (DDT) and 2,2-bis-(chlorophenyl)-1,1-dichloroethylene (DDE) on eggshell thickness and weight have been reported for many avian species.[1,2] These effects have been shown to occur both naturally[3-5] and in laboratory experiments.[6,7] Since the vast stockpiles of DDT and DDE constitute a problem from both the aspect of storage and the hazard of environmental pollution, an effort is underway to study the feasibility of detoxifying these insecticides. One of the more promising methods to date has been the treatment of DDT and DDE with sulfuric acid to produce a sulfonated derivative of the parent compound which is water soluble. These sulfonates are being tested for toxicity in a variety of animal systems. This paper reports the results of a study conducted to determine the effects of the sulfonated derivatives of DDT and DDE on eggshell formation in the duck.

II. MATERIALS AND METHODS.

Young adult mallard ducks (*Anas platyrhynchos*) were obtained from a local supplier and randomly assigned to cages with five hens and one drake per cage. The ducks were maintained on commercial poultry-laying mash (Purina Chow) and were allowed to acclimate for a period of 2 months. Egg production was induced by regulating the photoperiod; the ducks were first exposed to 8 hours of light per day for 4 weeks and then 16 hours of light per day for the remainder of the experimental period. Egg production began 3 weeks after 16 hours of light per day was instituted.*

When peak egg production was reached, the test compounds were added to the poultry-laying mash. The eight experimental groups (one drake and five hens each) were given 10 ppm and 50 ppm of DDT, DDE, DDT-SO_4, and DDE-SO_4, respectively; four control groups were maintained on the normal diet. The feed for the test groups was prepared by dissolving the DDT and DDE in acetone and the sulfonated compounds in distilled water. The feed was mixed in a Hobart food mixer for 20 minutes.

Eggs were collected daily from each group for 30 days and labeled to identify the group and date. The white and yolk were removed from the egg by making a small hole on each side of the eggshell and blowing on one side. The eggshells were air dried until measurements were made. Days were picked at intervals throughout the experimental period, and the eggshells collected on those days were measured (total 434 eggs). The measurements made were (1) weight (grams), (2) maximum length and width (cm), and (3) shell thickness (mm); four measurements of thickness were made around the girth of the egg with a micrometer. The R-value** was determined by dividing the weight by the product of the length times the width.[8] Statistical analysis of all data was done by Least Squares and Maximum Likelihood General Purpose Program.†

*Spann, J. Personal communication. 1974.

**$R = \dfrac{\text{weight}}{\text{length} \times \text{width}}$

†Walter R. Harrey, Ohio State University, 1969.

III. RESULTS.

In all statistical analyses performed, no differences were seen between dose levels of the compounds fed, and the 10 and 50 ppm groups are considered together. Figure 1 shows the measurements of eggshell thickness over the 30-day experimental period. There were no statistical differences in mean thickness of the eggshells of controls on the days measured; the mean value was .401 mm. As expected, the thickness of the eggshells from ducks fed DDE was significantly reduced ($p < .01$) for the entire experimental period. The eggshells from the ducks fed DDT remained as thick as the eggshells of the controls until day 14 but were significantly thinner ($p < .01$) for the remainder of the experimental period. The ducks fed DDT-SO_4 and DDE-SO_4 produced eggs with shells identical in thickness and were grouped together. It can be seen that the groups fed sulfonates laid eggs with the same shell thickness as that of the controls except on day 18; on day 18, there was a significant difference ($p < .01$) in eggshell thickness in comparison to that of the controls. The thickness returned to control levels at day 27 and remained as thick as the eggs of the controls for the remainder of the experiment.

Figure 2 shows the R-values* of eggshell thickness from ducks fed DDT, DDE, sulfonated derivatives, and control diets. A significant reduction in the R-value for eggshells from ducks fed DDT and DDE is seen when compared to controls. There was no significant difference among the R-values obtained for eggshells from ducks fed DDT-SO_4 and DDE-SO_4 and the eggshells from the controls. The DDT-SO_4 and DDE-SO_4 values did not vary significantly and were considered as one group.

Another parameter which also varied significantly was eggshell weight. The weights of eggshells of ducks fed DDT and DDE followed the same pattern as the thicknesses. There were no significant differences in weight among the groups of ducks fed DDT-SO_4 or DDE-SO_4 or used as controls.

Significant differences were also seen in the lengths and widths of eggshells from the ducks fed DDE-SO_4 and DDT. These differences were compensated for by using R-values. The purpose of the R-value is to correlate eggshell weight with size. As eggshell size may be related to other factors than the toxic effects of the compounds, this value gives an indication of weight in comparison to the overall size.

IV. DISCUSSION.

The results of this experiment show that, although DDT and DDE fed to mallard ducks at levels of 10 ppm and 50 ppm cause significant alterations in eggshell measurements such as thickness and weight and in R-values, their sulfonated derivatives do not share these characteristics. Although the sulfonated compounds cause a reduction of thickness at day 18, this decreased thickness is not as severe as that caused by DDT or DDE and is a transitory effect. The R-values show that DDT and DDE are potent agents in causing a reduction of the weight-to-size ratio of eggshells, but the sulfonated compounds cause no significant change when compared to controls. Our results show the sulfonated products of DDT and DDE to be less toxic to birds during egg production. Further studies with other animal systems are necessary to more fully characterize the toxicity of these compounds.

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* $R = \dfrac{\text{weight}}{\text{length} \times \text{width}}$

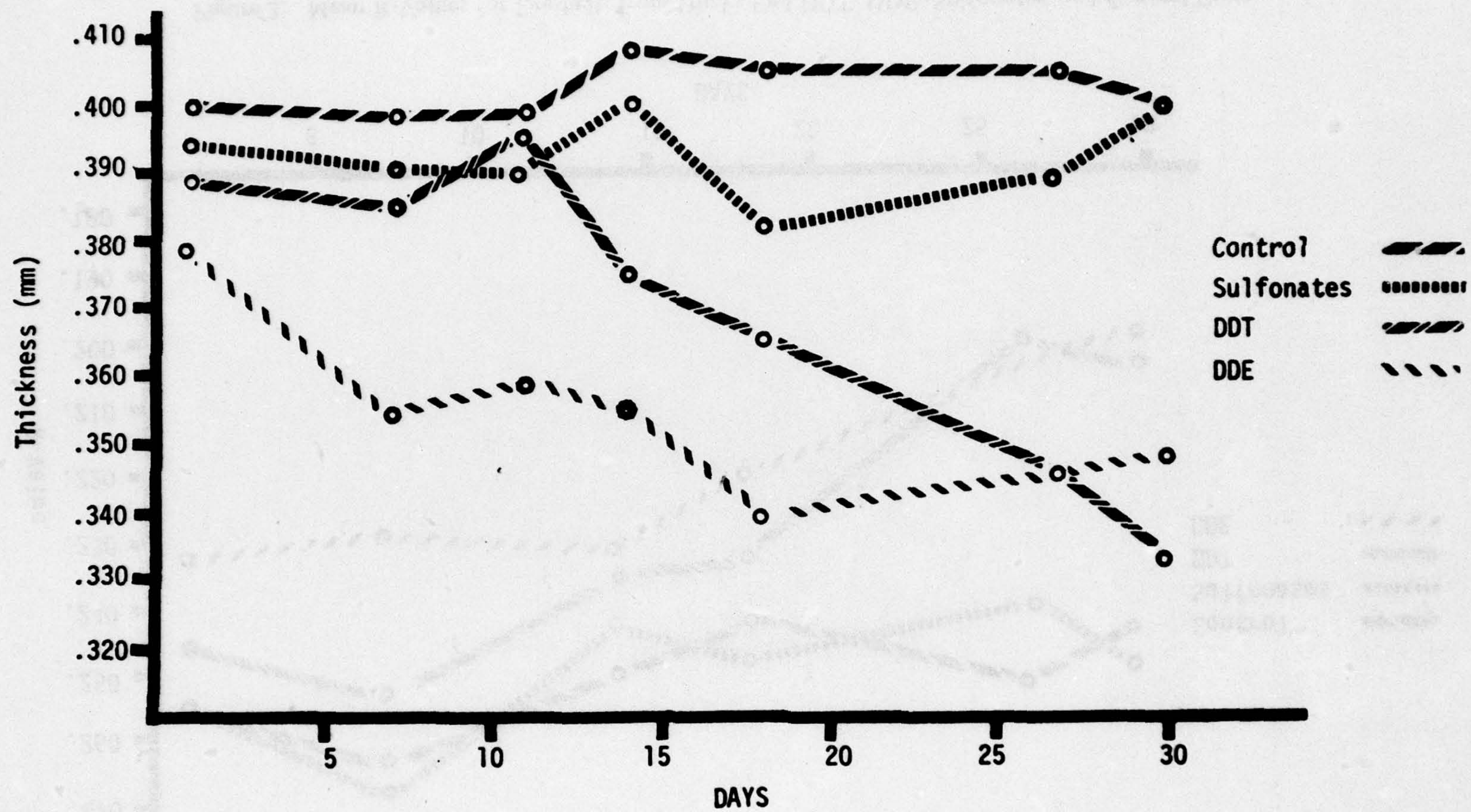

Figure 1. Mean Eggshell Thicknesses from Ducks Fed DDT, DDE, Sulfonates, and Control Diets

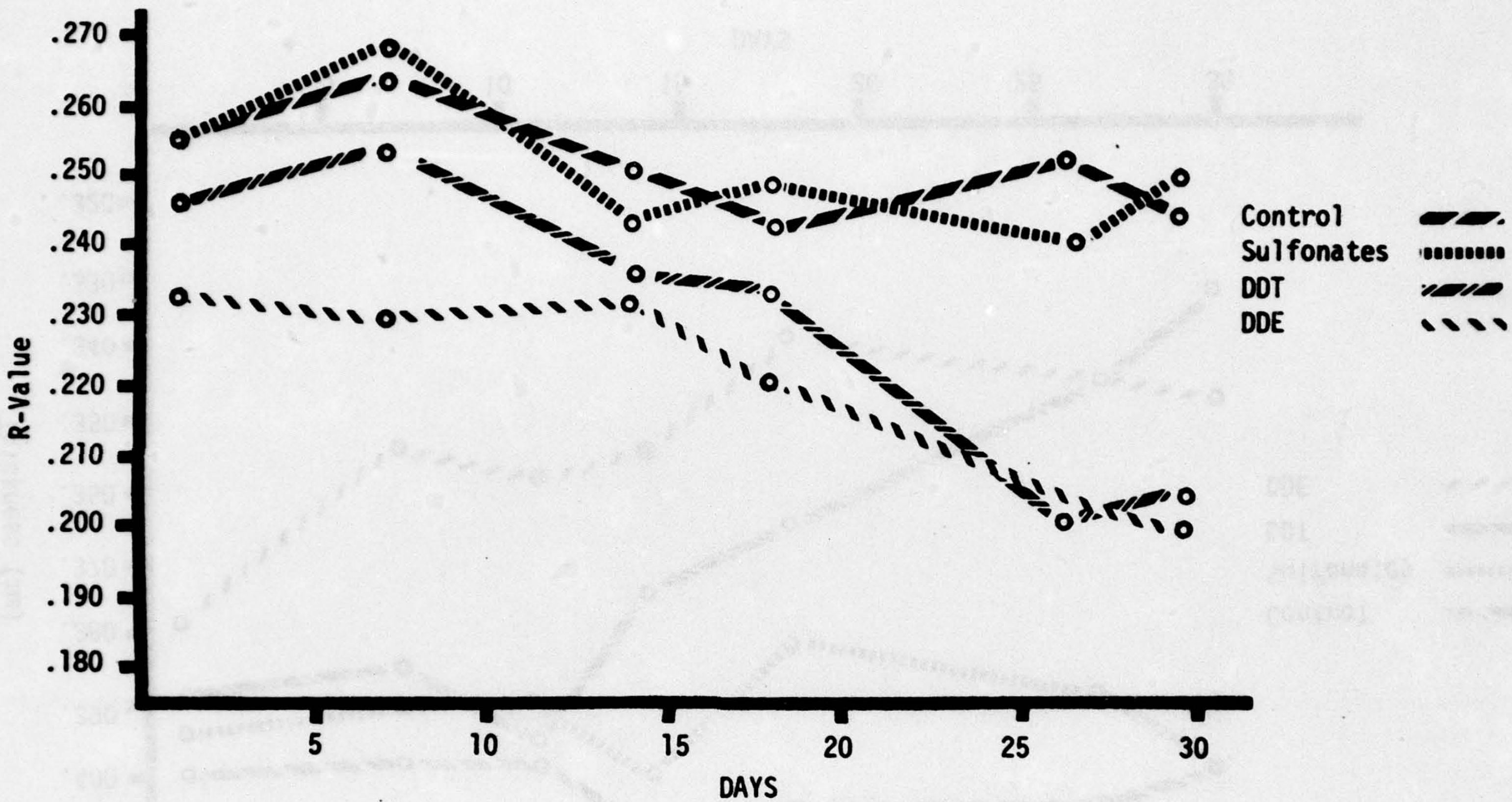

Figure 2. Mean R-Values for Eggshells from Ducks Fed DDT, DDE, Sulfonates, and Control Diets

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